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AUTHOR Cole, Herbert, Jr.
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ABSTRACT

This agriculture extension service publication from Pennsylvania State University discusses agricultural pesticide application equipment. The three sections of the publication are Power Sprayers, Power Dusters, and Aerial Equipment. In the section discussing power sprayers, subtopics include hydraulic sprayers, component parts, multi-purpose farm sprayers, and fog applicators. In the discussion of power dusters, subtopics include fans, distribution systems, mounting, and calibration. The subtopics in the discussion of aerial equipment include advantages and disadvantages of aerial application, swath width, type of aircraft, climate and operating conditions, and calibration. Some charts and diagrams are included where appropriate. (MR)

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POWER SPRAYERS, POWER DUSTERS, AND AERIAL EQUIPMENT FOR PESTICIDE APPLICATION

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College of Agriculture, The Pennsylvania State University, University Park, Pennsylvania

POWER SPRAYERS

Four classes of power-spraying and dusting equipment are used on farms:

- -Hydraulic sprayers
- -Air sprayers
- -Fog applicators or aerosol generators
- -Dusters

Models of these are available in several types and sizes. Some units are designed for specific spraying or dusting operations, and some are general-purpose units.

HYDRAULIC SPRAYERS

Hydraulic sprayers discharge the spray by the direct action of a pressure pump on a liquid spray material. The pressure forces the liquid spray through nozzles, which break it into droplets of the proper size and disperse them in the desired spray pattern.

Hydraulic sprayer units can be purchased complete or can be assembled from component parts. Five general classes of hydraulic sprayers are commercially available:

Small general-use sprayers
Multiple-purpose farm sprayers
High-pressure, high-volume sprayers
Low-pressure, low-volume sprayers
Self-propelled, high-clearance sprayers

COMPONENT PARTS

Different spray jobs call for different spraying pressures, different kinds and amounts of spray materials, and different methods of application. Therefore, in buying or assembling a sprayer, particular consideration must be given to the type and size of pump, the size of the tank, the method of agitating the spray material, the type of distribution system, and the nozzles.

PUMP

The pump (with other components) determines the spraying pressure and spraying capacity of the sprayer and the kinds of spray materials that can be handled. The types of pumps are compared in the chart on the following page.

The type and size of pump needed depends on the spray job. Some jobs are done best with low-pressure and high-volume spraying. Others require high pressure and low volume. The size of the job--the number of acres, plants, or trees to be sprayed--is an important factor.

COMPARISON OF SPRAYER PUMPS AVAILABLE

Type	Materials Handled	Durability	Operating Range (rpm)	Capacity in gallons/min at zero psi (approx.)	Maximum pressure in psi (approx.)
Roller.....	Almost any (with proper rollers)	Spraying pressure decreases with water, but worn rollers are easily replaced.	300 to 1,000	1 to 35	250 to 350
Piston.....	Any	Long life	100 to 600	1 1/2 to 60	800 to 1,000
Centrifugal..	Any	Long life	1,200 to 3,500	0 to 120	200
Diaphragm....	Any	Long life	200 to 1,200	1 to 10	100
Gear	Oil emulsions and non-abrasives. Not for wettable powders, except when gears are of nylon.	Limited life under adverse conditions. Spraying pressure and capacity decreases with wear.	500 to 1,800	5 to 20	100
Flexible impeller...	Wettable powders, mild abrasives.	Moderate	500 to 1,500	0 to 30	50
Sliding vane rotary....	Limited to oil and oil emulsions.	Spraying pressure and capacity decreases with wear.	500 to 600	5 to 20	125

Spraying recommendations vary with different crops, and may even vary for a particular crop. For example, on one crop, two different systems may be necessary:

Disease control might require spraying pressure of 200 to 400 pounds per square inch (psi) and an application rate of 75 to 150 gallons per acre (gal/A), and weed control may require spraying pressure of 40 to 80 psi and an application rate of 10 to 20 gal/A.

TANK

Sprayer tanks may be made of metal or fiberglass.

Factory-assembled sprayer units usually have a metal tank, coated inside with a chemical-resistant material. The tank usually has rounded corners inside to facilitate cleaning.

On farm-assembled units, the use of one or more 55-gallon drums is common. This reduces the cost of the sprayer, but the drums are more difficult to clean and usually less resistant to rust and chemicals than are tanks designed especially for sprayers. The drums may be mounted horizontally or vertically on a tractor or trailer.

Sprayer tanks should have a large covered opening in the top, fitted with a removable strainer to make filling, inspection, and cleaning easier. A drain plug should be in the bottom to permit complete drainage when cleaning.

Capacity of the sprayer tank on commercially available units is usually 10 to 20 times the pumping capacity of the pump. For example, a 20-gallon per minute (gal/min) pump would have a 200 to 400 gallon tank.

AGITATION OF SPRAY MATERIAL

The two methods of agitating the spray material in the tank are:

Mechanical--agitation provided by paddles or propeller; and

Hydraulic--agitation provided by the return flow of excess spray material from the pump.

Continuous, positive agitation is necessary in order to use the full range of spray materials. Mechanical agitation is considered better than hydraulic agitation. Excessive agitation of certain solutions and emulsions may cause foaming, heating, or other undesirable results. The label on the pesticide container may indicate the kind of agitation to use.

Mechanical agitation is usually provided with piston-type pumps and engine-run sprayers. Hydraulic agitation is often used with sprayers that have the pump driven by power take-off.

DISTRIBUTION SYSTEM

The four types of spray-distribution units are hand guns, automatic spray heads, spray booms, and boomless nozzles.

Hand guns are used for spraying fruit trees and livestock, for spraying in buildings, and for spraying herbicides along fence rows and industrial rights-of-way. They consist of one or more nozzles in a suitable mounting and a fast-acting control valve. The valve serves as a cutoff and as a means of adjusting the spray pattern. Some guns may have two valves--one for cutoff and the other for adjusting the spray pattern.

Automatic spray heads are sometimes used for orchard spraying. The nozzles are arranged on a vertical boom or series of booms.

Spray booms are designed for spraying field and row crops. They consist of a pipe or tubing on which nozzles are spaced and mounted. (The pipe or tubing can be a part of the system that supplies spray to the nozzles.) Nozzles are usually mounted horizontally on the sprayer and can be raised or lowered. The most common boom lengths for field spraying are 18 and 21 feet. Longer booms 30 feet and more in length are available.

Modified spray booms include single nozzles or sets of nozzles for band and directional spraying. Often one to four nozzles may be mounted on slides, skids, or wheels for controlled differential placement of pesticides in emerged crops.

Boomless nozzle, or broadcast, units consist of a single nozzle or a compact arrangement of nozzles mounted at the rear of a sprayer. They deliver a wide-swath spray pattern to a distance of 18 feet or more on one or both sides of the sprayer. They are less expensive, simpler to operate, and require less maintenance than boom units. However, accurate placement of the spray and uniform coverage of an area are difficult to obtain, because the slightest wind affects the spray pattern. The units are most effective in spraying herbicides along roadsides, ditchbanks, and fence rows. High-gallonage application rates are required.

NOZZLES

The nozzles determine the angle of spray, the type of spray pattern, the spray droplet size, and the rate of discharge.

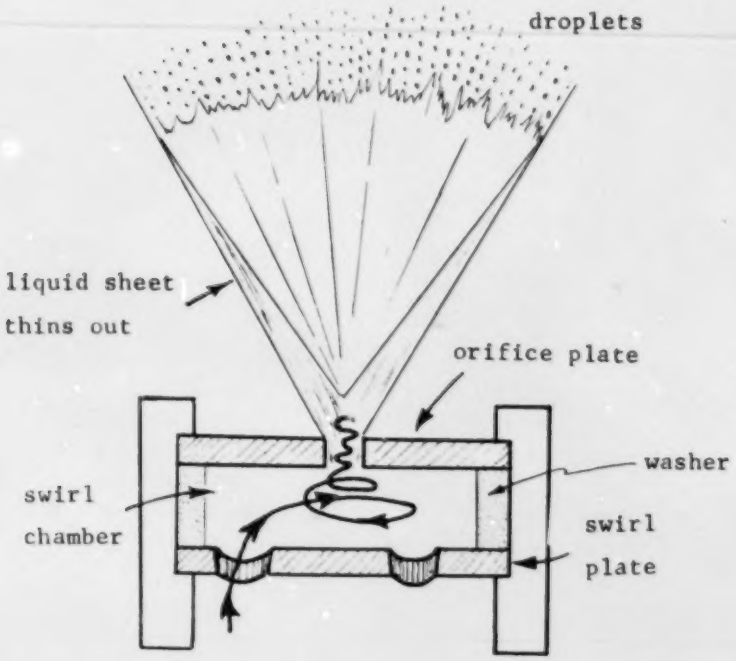
One set of nozzles may be adequate for a field sprayer. The spray pattern and angle and the discharge rate can be varied by changing the replaceable tips or disks. Nozzle manufacturers furnish charts showing the discharge rate of the different tip or disk combinations at different spraying pressures.

Spray pattern may be flat fan, hollow cone, or solid cone. The flat-fan pattern is commonly used for field crop weed spraying. Both the cone and flat-fan patterns are used in insect control.

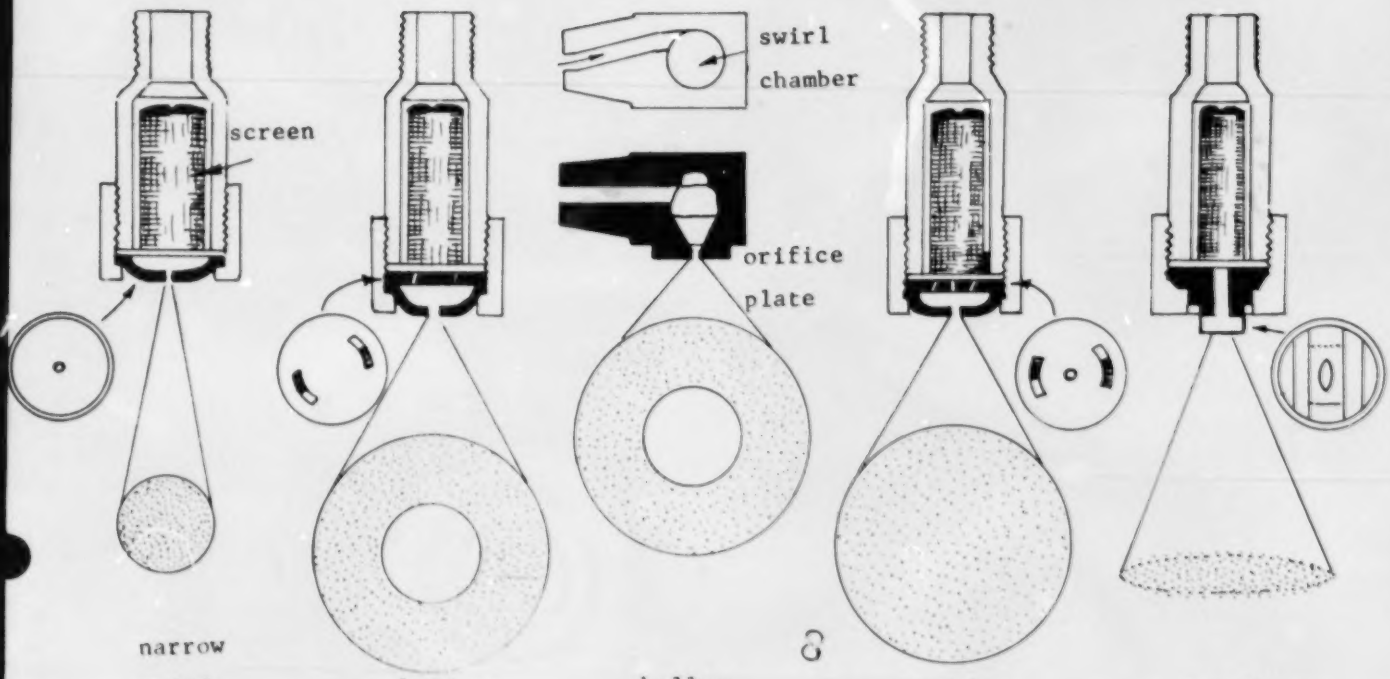
Metal, ceramic, and nylon nozzles are available. Stainless steel, hardened steel, or ceramic nozzles and tips or disks should be used to spray abrasive wettable powders.

Nozzle extensions or drop pipes are available for more accurate placement of the spray and for underleaf coverage in row-crops. Special kits may be obtained for attaching nozzles on a planter for preemergence weed control band spraying.

CROSS-SECTION OF A HOLLOW-CONE NOZZLE



SPRAYER NOZZLE PATTERNS



SMALL GENERAL-USE SPRAYERS

These sprayers include the power wheelbarrow sprayer, the "estate" or small wheel-mounted sprayer, and the small skid-mounted units. The last two are essentially the same sprayer on different mountings.

The sprayers are designed for jobs too large for hand equipment. Jobs for which they are used include garden spraying, small tree spraying, and nursery spraying.

Power wheelbarrow sprayers--smallest of the power-sprayer units--have reciprocating pumps (plunger or piston) that deliver 1 1/2 to 3 gallons per minute and develop pressures up to 250 pounds. Power is supplied by an air-cooled engine of 2/3 to 1 1/2 horsepower. (For greenhouse or other interior spraying jobs, a 1/2 to 3/4 horsepower electric motor can be used to operate the sprayer.) Tank sizes range from 12 to 18 gallons. Spray material in the tank may be mechanically or hydraulically agitated. Standard equipment includes adjustable hand gun and hose. Spray booms are available for some models.

Estate sprayers are small two-wheel mounted units that can be moved by hand. Trailer hitches for moving by vehicle are available as special equipment. Smaller models of these sprayers have 15- to 30-gallon tanks and pumps that deliver 1 1/2 to 3 gallons per minute at pressures up to 250 pounds. Larger models have 50-gallon tanks and pumps that deliver 3 to 4 gallons per minute at pressures of 250 to 400 pounds. Power is supplied by an air-cooled engine of 3/4 to 1 1/2 horsepower. Spray material in the tank is mechanically agitated. Standard equipment includes hand gun and hose; spray booms are available for some models.

MULTIPLE-PURPOSE FARM SPRAYERS

These sprayers are designed to handle all or most of the spraying needs on farms--from low-pressure weed or row-crop spraying (30 to 50 pounds) up to higher pressure fruit-tree, field-crop and livestock spraying (200 to 400 pounds or more.)

The sprayers have plunger- or piston-type pumps that deliver 3 to 8 gallons per minute at pressures up to 800 pounds. Tanks range in size from 50 to 200 gallons. The spray material is mechanically agitated.

Skid-mounted models are powered by an auxiliary engine. Wheel-mounted models may be powered by an auxiliary engine. Wheel-mounted models may be powered by an auxiliary engine or by tractor power take-off.

Hand gun and hose are standard equipment; field booms, 20 to 30 feet in length, are available as optional equipment.

HIGH-PRESSURE, HIGH-VOLUME SPRAYERS

These sprayers are used primarily by commercial applicators or growers for truck crops. They provide the high-pressure, high-volume spray delivery required for complete coverage of fruit trees in full foliage and the dense growth of vine and other truck crops.

The sprayers are similar in design to multiple-purpose sprayers, but have pumps and tanks with larger capacities. The pumps deliver 8 to 60 gallons per minute at pressures as high as 1,000 pounds. Tanks range in size up to 600-gallon capacity.

Field booms designed for use with these sprayers may be the adjustable type or of special design for use on one specific crop.

Hydraulically operated one-side booms are often used to reduce soil compaction (caused by the weight of the sprayer) that might injure the roots of potatoes, tomatoes, and other plants.

Hand guns or automatic spray heads are used for fruit-tree spraying.

LOW-PRESSURE, LOW-VOLUME SPRAYERS

These sprayers are designed primarily for 3 to 50 gallons-per-acre application at less than 100 pounds pressure for insect, disease and weed control in crops.

The sprayers usually have rotary-type pumps, and the spray material in the tank is hydraulically agitated. This limits their use to sediment-free spray materials.

Tractor-mounted models consist of a kit of component parts (pump, valves, pressure gauge, pressure regulator, spray boom, and brackets for mounting the boom and one or more metal drums) which mount on the tractor. The pump mounts on the tractor and is operated by tractor power take-off.

Wheel-mounted models may be operated by tractor power take-off or by a separate engine. They may have a conventional sprayer tank of 50- to 250-gallon capacity or one or more 55-gallon metal drums mounted on the trailer frame.

SELF-PROPELLED, HIGH-CLEARANCE SPRAYERS

These special-purpose machines are designed for spraying field and row crops that are too tall for conventional sprayers.

They consist of two basic units--a vehicle (or carrier) and a sprayer. The vehicle may be a tractor modified to clear plants 5 to 8 feet tall or it may be a specially designed, self-propelled chassis.

Units designed around a tractor usually have a multiple-purpose, skid-mounted sprayer, which is attached to the frame. They may have three or four wheels, with the power at the rear wheels.

Chassis-type units usually have a low-pressure, low-volume sprayer, powered by a separate engine. They usually have three wheels, with the power at one front wheel.

The spray boom is usually mounted on the rear of self-propelled, high-clearance sprayers, and it can be raised or lowered to permit spraying of high- and low-growing crops.

FOG APPLICATORS

Fog applicators, or aerosol generators, are not commonly used on field crops because of the type of spray produced. They are used mostly for temporary control of mosquitoes, flies, and other insects outdoors or in buildings and for pest control in green-houses.

The sprayers produce a fog, or mist, that remains in the air. The fog must contact the pest to be effective, since there is little or no residual action.

Outdoor applications are usually made at night when temperature, humidity, and wind conditions are most favorable. An application cannot be made under excessive wind conditions, but some air movement is required to disperse the spray over the area to be treated.

POWER DUSTERS

Power dusters are seldom used. They are usually classified by the method of powering--engine or tractor power take-off. They may also be divided into two general types--single-outlet units (one hose and nozzle) designed for orchard dusting, and multiple-outlet units designed for field- and row-crop work. Power dusters in general have these essential parts: Dust hopper with agitator and adjustable feed regulator, fan, distribution system (hose and nozzles), and power source.

The units available differ in the type and capacity or size of components, method of powering, and method of mounting.

DUST HOPPER

Dusters are available with hoppers that can hold from 2 to 4 cubic feet. Capacity of the hoppers is 60 to 200 pounds of dust, depending on the density of the dust.

Most units are equipped with internal-type agitators.

The feed regulators are adjustable to deliver dust at rates between 5 and 50 pounds per acre.

FANS

Centrifugal-type fans are commonly used on power dusters. The fan case is fitted with one or more outlets, the number depending on the number of hoses attached.

The fans generally operate at speeds of 2,200 to 3,400 revolutions per minute and deliver 500 to 1,000 cubic feet per minute of air at velocities of 50 to 100 miles per hour.

DISTRIBUTION SYSTEM

Fruit-tree dusters usually have one discharge hose and nozzle. Vineyard units have two hoses and nozzles.

Field- and row-crop dusters may have 4, 6, or 8 hoses and nozzles; some may have as many as 18. Outer ends of the hoses are mounted and spaced on a metal boom, 18 to 20 feet in length. The boom can be raised or lowered, and can be folded for transport.

For field-crop dusting, a tubular-type boom, 20 to 40 feet in length, is often used. It may have a series of discharge holes spaced on the bottom side or it may have an adjustable outlet slot.

Accessories are available for more effective dusting. Hose-support rods, for example, permit better dusting of low-growing crops and better underleaf coverage of rows.

MOUNTING

Engine-powered units may be mounted on a tractor or trailer or transported by truck or other vehicle. Units powered by tractor power take-off may be tractor or trailer mounted.

CALIBRATION

Before starting a dusting operation, check the application rate of the duster unit. Dust mixtures vary in density, and the application rate can vary at a given setting of the feed regulator.

Follow this procedure:

1. Measure off an area of at least 1/2 acre (21,780 square feet).
2. Fill the dust hopper and set the feed regulator for the desired application rate.
3. Dust the measured area. Drive at a constant rate of speed, because rate of speed affects the application rate. A tractor speedometer is recommended.
4. Refill the hopper from a weighed amount of dust. Subtract the weight of the remaining dust from the weight of the original amount. This gives the amount required to fill the hopper, and therefore the amount applied to the measured area.

AERIAL EQUIPMENT

(AERIAL APPLICATION MUST BE DONE BY A LICENSED AERIAL APPLICATOR)

The key to successful aerial application of pesticides is UNIFORMITY of the initial spray deposit over the plant canopy. The chemical will be redistributed by dew, rain, or overhead irrigation to other parts of the plant including lower leaf surfaces, stems and fruit. The key to uniform aerial application is the DESIGN and ADJUSTMENT of the spray distribution system and the OPERATION of the aircraft.

The advantages are summarized below. Most important is the speed of coverage to combat widespread and fast developing epidemics when they strike major crops such as corn, cereal grain, potatoes, and vegetables. One aircraft can do more work in an hour than most ground rigs can do in a day. Aircraft can spray fields that are too wet for ground equipment, which is often the case when fungus pests are most active.

ADVANTAGES OF AERIAL APPLICATION

1. Faster
2. Better timing
3. Works on wet fields following rain or irrigation
4. Only feasible way to cope with pest epidemics
5. Eliminates sprayer wheel damage and soil compaction
6. Reduces mechanical spread of virus and bacterial disease
7. Spray deposits resist weathering better
8. Uses less water
9. No runoff
10. Lowers grower's capital investment
11. Reduces labor requirements

DISADVANTAGES OF AERIAL APPLICATION

1. Some fields inaccessible or too uneven for successful flights
2. Inherent potential for environmental pollution and drift damage
3. Certain crops not suited to aerial application

EQUIPMENT AND OPERATION

AIRBORNE-AIRBLAST SPRAYER

To consider an agricultural aircraft an "airborn-airblast sprayer" will put its function into better focus. Its efficiency depends on its adjustment and operation. The airstream from a fixed wing aircraft or helicopter moves outward and downward. The objective is to put the spray into this stream of air in such a manner that it comes out uniformly across the crop when spraying is completed. Swaths must overlap properly. The upper canopy of foliage is a primary target for insects and diseases of most crops. Penetration of vertical distribution will be adequate for most crops, except in unusual situations.

SWATH WIDTH

Most aircraft in calm air will disperse some spray to a width about twice that of the wingspan. The effective swath width is governed mainly by the weight and wingspan. Tight swaths give better lateral surfaces, perhaps even to the undersides of leaves. For most field and vegetable crops, swaths at just beyond the wingspan of 36 to 40 feet for light aircraft and up to 45 feet for heavier craft are suggested. Optimum swath for helicopters is usually 5 to 10 feet beyond the normal boom length.

FLAGGING

Swaths should be marked at the end of the field with permanent flags or by a flagman. Swaths should be measured accurately with a chain or other device except when rows can be accurately counted. Test plots should be at least three swaths wide to avoid mixing of treatments.

SPRAY VOLUME

Experience has shown that the volume of aerial spray can be reduced significantly with no real loss in disease control. Whereas five to ten gallons per acre was considered minimal a few years ago for field and vegetable crops, volume of two and three are now used successfully. This necessitates well-designed and operated spray systems of either boom-nozzle or Micronair types. The water or other liquid vehicle in the spray serves no other function than to keep the mixture fluid until it is delivered to the target on the plant. Only sufficient water is needed to make the chemical sprayable. On vegetables and field crops, two to three gallons of spray volume per acre is considered optimum. Most orchard crops and vineyards can be handled with volumes up to five gal/A. Some very unusually tall or dense foliage crops or situations requiring greater penetration to the lower surfaces may benefit from slightly higher volumes, if aerial application is at all feasible. A slight increase in normal volume may be desirable under unusually low humidity conditions if some type of non-volatile carrier cannot be used. Spray volume is not nearly as important as the uniformity of the distribution of the chemical into the airstream of the aircraft.

SPRAY ADJUVANTS

The initial spread and coverage of the spray can be enhanced with a spreader-sticker on many hard-to-wet crops because they are smooth, waxy, or hairy. Properly chosen, such materials, sometimes known as surfactants, will greatly improve initial retention and will also aid redistribution without excessive runoff. Certain emulsifiable spray oils have also been used to advantage with aerial sprays. They improve spreading, tenacity, and redistribution and tend to reduce the evaporation of the spray in flight.

Ordinary household detergents or herbicide spray adjuvants are not recommended as agricultural spray adjuvants. They may cause too much foam, excessive runoff, and may lower the tenacity of the spray deposit.

TYPE OF AIRCRAFT

Any of the commonly used makes and models of fixed wing or rotary agricultural aircraft will work if they have a good spray distribution system and are operated within their airmoving capacity. This is determined mostly by wingspan, weight, and speed. The aircraft is nothing more than the vehicle to haul the load. The choice will be governed by the type of operation and to a large extent the preference of the operator.

SPRAY DISTRIBUTION SYSTEMS

Boom-nozzle or Micronair Rotary Atomiser sprayers are satisfactory for most fungicides and insecticides. Ultra-low-volume application such as "Mini-Spin" equipment is adaptable to certain insecticides but not fungicides.

BOOM-NOZZLE SYSTEMS

The majority of aircraft are equipped with boom-nozzle spray distribution systems. Either wing-enclosed or trailing-edge booms are satisfactory. Some homemade ones are a "plumbers nightmare."

NOZZLE SPACING AND PLACEMENT

On most aircraft, including helicopters, nozzles must be positioned asymmetrically (irregularly) on the boom, clustered or spread out as required at certain points to compensate for the distortion of the airstream by the propeller or from secondary eddies caused by the fuselage or wheels.

The larger the engine and propeller the greater the distortion will be. Regular or symmetrical spacing of nozzles produces a streaked, uneven pattern except on light, high-winged monoplanes. Many "customized" booms, especially after modifications according to the fancy of the operator, put out a very irregular spray pattern. Factory-installed booms with clustered nozzles as used on "Pawnees" and "Agcats" usually provide a uniform spray pattern. Unfortunately some new models of agricultural aircraft, although they are efficient aerial vehicles, are coming out of the factory with poorly designed spray booms (symmetrical and wingtip nozzles) that will require major modification and nozzle relocation. Most helicopters require minor clustering of certain nozzles to even out the pattern.

WINGTIP VORTICE

All aircraft produce a certain amount of vortice roll at the end of the wings or rotorblades. This can be used to advantage in aerial spraying if the spray released into the entrained air can be kept under control. If the boom is too long on a fixed wing aircraft, too much of the spray may be dispersed into upper air currents where it will be lost and subject to excessive drifting. To prevent this, nozzles should not be used within two to three feet of the wingtip. The so called "high-capacity booms" with nozzles to the wingtip or beyond may be used for high-altitude, wide-

swath, drifting-type application of insecticides to forest trees, but are not recommended for applying fungicides. Similarly, if the boom on a helicopter is too long, some spray will be released beyond the effective force of the rotor tip vortices. Helicopter booms should be only a few feet longer than the span of the rotors.

NOZZLE TYPE

Hollow-cone nozzles such as Spraying Systems No. 4664 Diaphragm TeeJet fitted with a core (whirlplate) and orifice disc are recommended. "Whirl-jet" or flat-fan nozzles are not recommended because they are highly subject to wear and soon produce irregular droplet patterns. Discs and cores of cone nozzles are easily and economically replaced when worn.

NUMBER AND SIZE OF NOZZLES

For spray volumes of 2 to 4 gal/A, 20 to 30 well-placed nozzles are adequate. For volumes of 5 to 10 gal/A, 30 to 44 properly spaced nozzles are suggested. D-4 and D-6 with No. 45 cores are suggested for the lower volumes. D-8 to D-12 with No. 45 or No. 46 cores will be required for the high volumes. The final choice of the number and size of the nozzles depends upon the airspeed, pressure, and volume desired. Preliminary calculations can be made from manufacturer's nozzle capacity charts. Sizes can be mixed to change the output at strategic spots on the boom.

CONTROLLING DROPLET SIZE

The shear forces of the air passing over the face of the nozzles exert a far greater influence on droplet size than the pressure, airspeed or size of orifice used in normal application. The droplet size can be altered considerably by changing the angle of the nozzle into the airstream. The spray volume remains the same with no change in pressure or orifice size.

Nozzles pointing straight down or slightly backward will approximate the desired breakup of the spray for insecticide or fungicide application. Slightly smaller discs or higher pressures may be necessary on helicopters because of the slower flying speeds.

Nozzles pointing forward usually cause too much breakup and create droplets that are too fine and subject to drifting.

The nozzle pointed backward produces a very coarse spray, more subject to streaking and uneven coverage.

Changes in the nozzle angle can be made quickly on the entire boom if it is fitted with a flexible coupling and adjustable mounting. Streamlined or fixed booms that cannot be turned can be adjusted by turning the individual nozzles sideways or downward to the desired angle.

PUMPS AND PRESSURE

High-capacity pumps with one- or two-inch discharge are desirable on aerial sprayers for the relatively high volume and bypass agitation required for wettable powders. Operating pressures usually range between 25 to 50 psi for nozzle systems. With soluble materials or emulsions, less agitation is needed.

MICRONAIR ROTARY ATOMISER

This equipment has been used very successfully with pesticides on a large variety of crops. The individual units consist of propeller-driven rotating wire mesh cylinders. The spray mixture is pumped at low pressure to a central spindle and is discharged by centrifugal force. Droplet size is readily changed by adjusting the variable pitch blades on the units. The faster the rotation the finer the droplets. Droplet size remains relatively consistent regardless of the volume of spray being applied per acre. The delivery rate is altered quickly by adjusting the bypass or flow rate of the pump. The earlier standard model consisted of five rotating cages. The new compact model, AU3000, with two cages, is lighter in weight. It can apply adequate gallonage for fungicides, yet is readily adapted to ultra-low volume insecticide use.

The Micronair Rotary Atomiser produces droplets of a more uniform size than a conventional nozzle. Spray volume of two to three gallons per acre is standard for Micronair and usually somewhat lower than boom-nozzle systems. Four atomisers are suggested for standard aircraft and six for the larger. Operating swath widths are the same as conventional boom systems on a given aircraft. Slightly higher flying altitude is suggested with Micronair equipment to permit full blending of the individual spray streams. Rotary atomizers have a tendency to put out ultra-fine droplets. Operators are cautioned to avoid droplets that are so fine they result in waste and drift hazard. The initial cost of rotary atomizers is higher than a boom nozzle system, but this is offset by economies in operation and maintenance with greater flexibility.

HELICOPTERS

Helicopters equipped with boom sprayers are used successfully for the application of pesticides on a wide variety of crops. They have the distinct advantage of being able to work small and obstructed fields. They do not require airstrips, and considerable ferrying time may be saved. The same gallonage rates recommended for fixed-wing, boom-nozzle sprayers are also recommended for helicopter application. The penetration of dense foliage is excellent with a helicopter at slow to moderate flying speeds. However, at normal operating speeds of 40 to 60 mph, the penetration of foliage has often been overemphasized. It is not necessary except in unusual cases because redistribution of the initial spray deposit corrects the irregularities. Helicopter operators are cautioned not to exceed optimum swath widths and flying speeds for the particular size and weight of helicopter being operated.

CLIMATE AND OPERATING CONDITIONS

WIND

A wind of two to six miles per hour is considered ideal, but aerial applications can be made in steady winds of up to ten to twelve miles per hour with little loss in effectiveness. Suitable adjustments should be made in droplet size under these conditions. Applications should be avoided in gusty winds or during the heat of the day when there are rising thermal air currents. Contrary to popular belief, sprays applied during dead calm and especially under temperature inversions fail to settle properly and may create serious drift problems. For convenience and efficiency, rows are usually planted the long way of the field and flown in the same direction If there is a choice, a light crosswind during spraying is advantageous to equalize the distribution of the spray within the swath and between swaths and should be used whenever possible. In higher winds it may be better to fly up and downwind.

RAINFALL AND DEW

Sprays may be applied when plants are dry or wet with dew, rain or irrigation. Moisture on the plants at the time of spraying helps spread the initial spray deposit. Rewetting the foliage will redistribute the spray. Where permanent or solid set irrigation systems are installed, the water may be turned on for a few minutes to wet the foliage and then shut off before spraying each particular set.

CHECKING SPRAY PATTERNS

THE IMPORTANCE OF PRE-CHECKING EACH AIRCRAFT FOR DROPLET SIZE, UNIFORMITY OF PATTERN, SWATH WIDTH, AND SPRAY VOLUME CANNOT BE OVEREMPHASIZED. THIS MUST BE DONE BY ACTUAL TESTS.

DROPLETS SIZE AND DISTRIBUTION

A reasonably accurate job of checking the spray characteristics of an aircraft can be done on the airstrip. Some dyes will make a good pattern of pesticide particle size and concentration on semi-smooth finish or sign-stock paper. Highly absorbent composition paper or slick black plastic is not satisfactory. Tapes and strips blow about too much. Cards or small sheets of heavier stock can be stapled or tacked about two feet apart to wood strips and laid across the line of flight. A single pass at normal altitude should be made first. This will show the droplet size range, any gross irregularities in the pattern, and the width or lateral dispersion of the spray. An additional pass on either side at the projected swath width will show the degree and uniformity of the overlap. Corrective changes in nozzle location (uniformity), nozzle angle (droplet size), or swath-width (overlapping) can be made where indicated. Achieving a good spray pattern is largely a matter of trial and error, but pattern studies are necessary steps to accomplish this end.

All airspray equipment should be carefully checked before the active spray season to avoid unnecessary and costly delays or faulty application with improperly serviced and adjusted equipment. Rechecks should be made during the season whenever changes are made in the spray distribution system.

CALIBRATION

The spray volume must be known precisely in order to achieve the proper rate of chemical per acre. Once the swath width is established from the pattern tests and the airspeed is known, further adjustments in volume can be achieved by changing the size of the nozzle discs and whirlplates or the pressure. Manufacturers nozzle specification charts should be consulted to make preliminary selection of nozzles. Calibration may be done by flying over a measured distance or by flying for a given length of time. The details of these methods are given in the following tables.

COMPUTATION OF ACREAGE AND MATERIALS

FORMULA: Acres covered = $\frac{\text{Length of swath in miles x width of swath in feet}}{8.25}$

The number of acres in a swath of given width and length can be determined from the chart below.

Example: An aircraft with a 40-foot effective swath treats a strip one mile long. To find the number of acres, follow the 40-foot vertical column down until it intersects the 1-mile line. The answer to the nearest tenth is 4.8 acres. For swath widths other than those shown, interpolate or use combinations of the figures shown.

To determine the amount of pesticide required, multiply the acres by the desired rate of application.

ACREAGE CHART

Swath Length (Miles)	30' Swath	35' Swath	40' Swath	45' Swath	50' Swath	75' Swath	100' Swath	200' Swath	300' Swath	500' Swath
1/4	.9	1.1	1.2	1.4	1.5	2.3	3.0	6.0	9.1	15.2
1/2	1.8	2.1	2.4	2.7	3.0	4.5	6.1	12.1	18.2	30.3
3/4	2.7	3.2	3.6	4.1	4.6	6.8	9.1	18.2	27.3	45.4
1	3.6	4.2	4.8	5.5	6.1	9.1	12.1	24.2	36.4	60.6
2	7.2	8.4	9.8	10.9	12.1	18.2	24.2	48.5	72.7	121.2
3	10.8	12.6	14.5	16.4	18.2	27.3	36.4	72.7	109.1	181.8
4	14.4	16.8	19.4	21.8	24.2	36.4	48.5	97.0	145.4	242.4
5	18.0	21.0	24.2	27.3	30.3	45.5	60.6	121.1	181.8	303.0

AIRCRAFT CALIBRATION

FORMULA: $\text{Acres per minute} = \frac{2 \times \text{swath width} \times \text{miles per hour}}{1{,}000}$

The chart below shows the rate, in acres per minute, at which spray or dry material can be applied when swath width and speed of aircraft are known. For swath widths or aircraft speeds other than those shown, interpolate or use combinations of the figures shown. To find the rate of flow in gallons per minute or pounds per minute, multiply the acres per minute by the number of gallons or pounds per acre to be applied.

Example: A 100 mile-per-hour aircraft has a 40-foot effective swath. Follow the vertical 40-foot column down until the figure opposite 100 miles per hour is intersected. The aircraft would cover 8.0 acres per minute. If 1 gallon of spray is to be applied per acre, the aircraft should be calibrated to disperse liquid at the rate of 8 gallons per minute. If 10 pounds of dry material is to be applied per acre, the aircraft should be calibrated to disperse material at the rate of 10 x 8.0, or 80 pounds per minute.

ACRES-PER-MINUTE CHART

Speed M.P.H.	30' Swath	35' Swath	40' Swath	45' Swath	50' Swath	75' Swath	100' Swath	200' Swath	300' Swath	500' Swath
75	4.5	5.2	6.0	6.7	7.5	11.2	15.0	30.0	45.0	75.0
80	4.8	5.6	6.4	7.2	8.0	12.0	16.0	32.0	48.0	80.0
85	5.1	5.9	6.8	7.6	8.5	12.7	17.0	34.0	51.0	85.0
90	5.4	6.3	7.2	8.1	9.0	13.5	18.0	36.0	54.0	90.0
95	5.7	6.6	7.6	8.5	9.5	14.2	19.0	38.0	57.0	95.0
100	6.0	7.0	8.0	9.0	10.0	15.0	20.0	40.0	60.0	100.0
110	6.6	7.7	8.8	9.9	11.0	16.5	22.0	44.0	66.0	110.0
120	7.2	8.4	9.6	10.8	12.0	18.0	24.0	48.0	72.0	120.0
130	7.8	9.1	10.4	11.7	13.0	19.5	26.0	52.0	78.0	130.0
140	8.4	9.8	11.2	12.6	14.0	21.0	28.0	56.0	84.0	140.0
150	9.0	10.5	12.0	13.5	15.0	22.5	30.0	60.0	90.0	150.0

Compiled by Herbert Cole, Jr., Professor, Plant Pathology. Appreciation is expressed to Rohm and Haas Co. for use of information from their publication, "Aerial Applicators Manual--For Application of Fungicides."

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